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National Hydrology Research Institute
Institut national de recherche en hydrologie

Inland Waters and Lands Directorate
Saskatoon, Saskatchewan, Canada

Direction générale des eaux intérieures et les terres
Saskatoon, Saskatchewan, Canada

Canada

O. MOKIEVSKY-ZUBOK

Mountain Hydrology Section
Surface Water Division
National Hydrology Research Institute
Environment Canada

GLACIER MASS BALANCE FOR 1987 ON SENTINEL, HELM AND PLACE GLACIERS BRITISH COLUMBIA

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GLACIER MASS BALANCE FOR 1987 ON SENTINEL, HELM AND PLACE GLACIERS, BRITISH COLUMBIA

General

In 1987 mass balance studies continued on three glaciers in southwestern British Columbia. Two of them, Sentinel Glacier and Place Glacier were former IHD (International Hydrological Decade) glaciers. Helm Glacier was added in 1976 for two major reasons:

a) it has strikingly different behaviour from Sentinel Glacier only 10 km away in spite of a similar elevation range and aspect; and

b) it contributes meltwater runoff to a B.C. Hydro reservoir.

Of the three glaciers, Sentinel Glacier had positive mass balance of +0.15 m of H_2O while Helm and Place glaciers had negative mass balance of -0.79 m and -0.85 m of H_2O respectively.

For each glacier the height of equilibrium line was established and summer runoff estimated.

Location

All three glaciers are located in the Coast Range mountains within 135 km of Vancouver, B.C. (Fig. 1).

The coordinates are:

Sentinel Glacier, lat. 49°54'N, long. 122°59'W
Helm Glacier, lat. 49°58'N, long. 123°00'W
Place Glacier, lat. 50°26'N, long. 122°36'W

General Description

Sentinel Glacier is located in Garibaldi Provincial Park, in British Columbia. The glacier meltwaters drain into 8 km long Garibaldi Lake at an elevation of 1486 m a.s.l. Sentinel Glacier is strongly influenced by a maritime climate and its mass balance is primarily determined by high winter precipitation with seasonal snow cover ranging from 4 m at its snout to more than 10 m at higher elevations. As a result the glacier has had a predominantly positive mass balance since the studies began in 1965. Out of 22 years of observation, 16 balance years were positive and 6 were negative. However, the glacier tongue is in retreat. When the studies began, the area of the glacier was 1.99 km^2. In 1987 the area was reduced to 1.70 km^2.

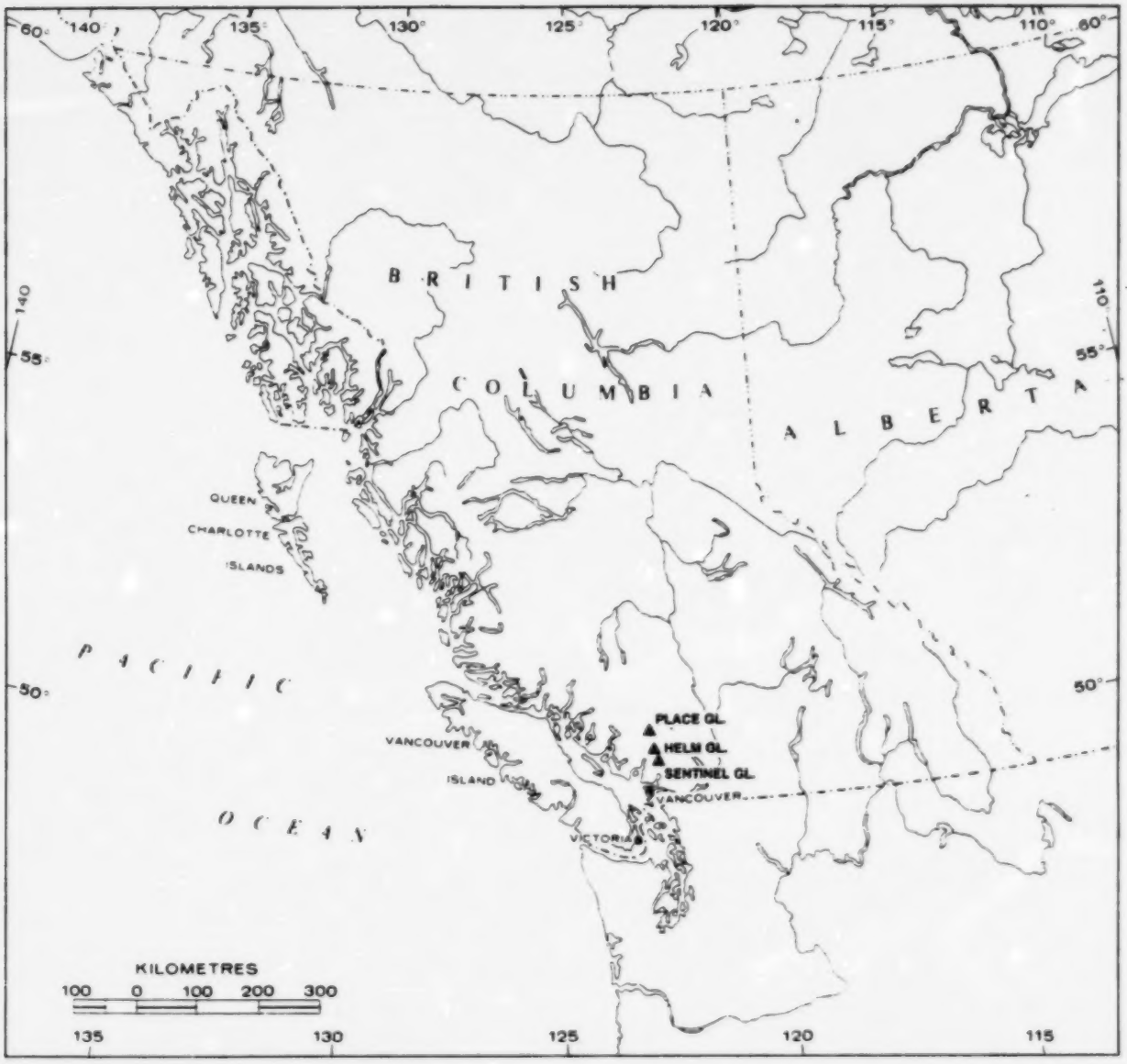

FIGURE 1 LOCATION OF GLACIERS SELECTED FOR MASS BALANCE STUDIES ON THE CANADIAN WEST COAST

Helm Glacier is also located in Garibaldi Provincial Park. The glacier meltwaters drain into the Cheakamus River system, contributing its flow to Daisy Lake, a B.C. Hydro water storage reservoir. Although Helm Glacier is situated only 10 km north of Sentinel Glacier it is outside of the heavy precipitation belt and its seasonal snow cover is substantially lower. Located in a valley surrounded by high ridges, the glacier has regularly shown a negative mass balance. In 1987 the net balance was again negative. The glacier is rapidly losing in volume and surface area. From 2.94 km^2 in 1977 Helm Glacier lost 1/3 of its surface area, i.e. 0.99 km^2, and now exposes a subglacial lake.

Place Glacier is located in the Coast Mountain Range, 135 km north of Vancouver. This glacier is influenced by a maritime climate; and seasonal snow cover rarely exceeds 5 m anywhere on the glacier. Since 1965 the glacier has had a predominantly negative mass balance and 1987 was no exception. It was the 11^{th} consecutive year of negative results. Since 1965 the area of the glacier decreased from 3.96 km^2 to 3.63 km^2 in 1987.

Summary of Results and Discussion

The results of the 1987 studies are presented in tables and graphs at the end of the report.

Table 1 shows mass balance data, including winter and summer balance components and other relevant information for Sentinel, Helm and Place glaciers. Net balance was determined on the basis of field measurements of both components i.e. winter snow accumulation and summer melt of snow, firn and ice, and in strict compliance with internationally agreed upon study methods[1), 2)] permitting direct world-wide comparison.

Winter balance was obtained from ground measurements by probing snow at 50 m intervals along cross profiles on sounding lines and at 100 m intervals along longitudinal profiles. Density measurements were taken from at least 3 snow pits at each glacier. Snow and ice melt were observed periodically during the summer at 68 ablation stake locations over the glacier surfaces.

Tables 2, 3 and 4 show detailed calculations of winter, summer and net balances by 100 m elevation bands. Summaries of mass balance data from 1964 to 1987 are given in references 3), 4) and 5). Following the tables, there are graphs for each glacier, showing the variation of winter, summer and net balances with elevation. Cumulative mass balance graphs (Figs. 5 and 6) show net changes in glacier storage. As a result of the heavier snowpack than at other glaciers, Sentinel Glacier had a light positive balance of +0.15 m of water, averaged over the entire glacier surface. Helm and Place Glaciers had average winter accumulation and produced negative mass balances of -0.79 m and -0.85 m of water respectively. Helm Glacier has consistently shown a negative balance for

all the years it has been under observation. In 1987 it lost a substantial portion of shallow ice in the lower western half, revealing a subglacial lake and exposing rock terrain.

The net balance, which represents the net loss from glacier storage in water equivalents was as follows:

on Helm Glacier	$1.54 \times 10^6 m^3$
on Place Glacier	$3.07 \times 10^6 m^3$

Since Sentinel Glacier showed a positive mass balance, there was no net decrease in glacier storage. There was however, melt from winter snow during the summer and from the exposed glacier ice towards the end of summer but this amount of water is less than the amount of snow deposited on the glacier. As a result Sentinel Glacier gained $0.26 \times 10^6 m^3$ of water, and, paradoxically in the year, retreated 5.5 m at the terminus.

By the end of the ablation season there was an insignificant amount of winter snow left on Helm Glacier, not enough to employ two methods in determining mass balance and to establish the internal consistency of measurements. This was, however, possible on Sentinel and Place glaciers, and internal consistancy was established for both glaciers, as is shown in Table 1 under "difference in measurement". The percentages of 6.5 for Sentinel and 3.1 for Place are within the limits of the technique and indicate good internal consistency.

The change in clacier storage during the study period is shown in Figures 5 and 6 updated from last year's report[5]. For both Place and Helm glaciers the overall trend is still negative (Fig. 6), while the trend for Sentinel Glacier is slightly negative for the period 1976 to 1987 but is strongly positive if the study is taken back to 1965 (Fig. 5). It is obvious that a real trend of glacier changes can only be established from long-term records obtained from control glaciers.

References

1. Mokievsky-Zubok, O. 1973. Determination of Mass Balance on Sentinel Glacier, British Columbia, Canada. Scientific Series #30 Inland Waters Directorate, Water Resources Branch, Ottawa.

2. Østrem, G. and Stanley, A.D. 1966 rev. ed. 1969 Glacier Mass Balance Measurement: A Manual for Field Work and Office Work, Dept. of Energy, Mines and Resources, Ottawa.

3. Mokievsky-Zubok, O., Ommanney, C.S.L., Power, J. 1985. NHRI Glacier Mass Balance, 1964-1984 (Cordillera and Arctic) NHRI, Environment Canada.

4. Mokievsky-Zubok, O. 1985. Glacier Mass Balance Results for 1985 in Southwestern and Northern British Columbia, Internal Report; Glacier section, NHRI, Environment Canada.

5. Mokievsky-Zubok, O. 1986. Glacier Mass Balance for 1986 on Sentinel, Helm and Place Glaciers, British Columbia. Internal Report, Cold Regions Section, NHRI, Environment Canada.

Table 1

SELECTED INFORMATION ON SOME WEST COAST GLACIERS STUDIED IN 1987

Coordinates		PLACE 50°26'N 122°36'W	HELM 49°58'N 123°00'W	SENTINEL 49°54'N 122°59'W	REMARKS
Elevation range m*		1860–2600	1810–2130	1630–2100	
Azimuth		329°	340°	291°	
Area covered by ice in km^2		3.63	1.95	1.70	
Winter Balance (accumulation)	$10^6 m^3$	7.05	4.15	4.98	
	sp, m**	1.94	2.13	2.92	
Summer Balance (ablation)	$10^6 m^3$	10.12	5.69	4.72	
	sp, m**	2.79	2.92	2.77	
Net balance	$10^6 m^3$	-3.07	-1.54	+0.26	
	sp, m**	-0.85	-0.79	+0.15	
Difference of measurement in % ***		3.1	1)	6.5	
Amount of remaining snow cover ****	$10^6 m^3$	0.37	1)	1.03	
	sp, m**	0.10		0.60	
Vertical ice loss at terminus nr. the lowest stake in m. of w. equiv.		3.0	3.1	2.7	
Area of exposed ice or ice and firn at end of season in km^2		2.49	1.75	0.43	
Equilibrium line elevation in m		2310	2030	1875	
Period of study		May 9 to Sept. 27, 1987	May 7 to Oct. 2, 1987	May 4 to Oct. 1, 1987	

* To the nearest 10 m.

** Values are given in "specific water equivalents" in metres-the specific values are obtained by dividing total mass of water by area-thus indicating the depth of water over the entire glacier.

*** Degree of internal consistency of measurements in comparing results obtained by two separate methods.

**** Amount of winter snow at the end of melt season.

1) No significant amount of winter snow left at end of melt season.

TABLE 2

1987

SENTINEL GLACIER
MASS BALANCE

ELEVATION INTERVAL IN m	AREA km^2	WINTER BALANCE Total $10^6 m^3$	WINTER BALANCE Specific m	SUMMER BALANCE Total $10^6 m^3$	SUMMER BALANCE Specific m	NET BALANCE Total $10^6 m^3$	NET BALANCE Specific m	REMARKS
< 1600								
1600–1700	0.054	0.149	2.759	0.257	4.759	0.108	-2.000	
1700–1800	0.277	0.701	2.531	1.164	4.202	0.463	-1.671	
1800–1900	0.515	1.458	2.831	1.612	3.130	0.154	-0.299	
1900–2000	0.490	1.529	3.120	1.058	2.159	0.471	+0.961	
2000–2100	0.346	1.054	3.046	0.596	1.723	0.458	+1.323	
2100–2200	0.023	0.086	3.739	0.029	1.261	0.057	+2.478	
TOTALS	1.705	4.977	2.919	4.716	2.766	+0.261	+0.153	

TABLE 3

1987

HELM GLACIER
MASS BALANCE

ELEVATION INTERVAL IN m	AREA km^2	WINTER BALANCE Total $10^6 m^3$	WINTER BALANCE Specific m	SUMMER BALANCE Total $10^6 m^3$	SUMMER BALANCE Specific m	NET BALANCE Total $10^6 m^3$	NET BALANCE Specific m	REMARKS
1800-1900	0.564	1.025	1.817	2.238	3.968	1.214	-2.151	
1900-2000	0.712	1.442	2.025	1.993	2.799	0.552	-0.774	
2000-2100	0.561	1.372	2.446	1.262	2.250	0.110	+0.196	
2100-2200	0.115	0.316	2.748	0.201	1.748	0.295	+1.000	
TOTALS	1.952	4.155	2.129	5.694	2.917	-1.539	-0.788	

TABLE 4

1987

PLACE GLACIER
MASS BALANCE

ELEVATION INTERVAL IN m	AREA km^2	WINTER BALANCE Total $10^6 m^3$	WINTER BALANCE Specific m	SUMMER BALANCE Total $10^6 m^3$	SUMMER BALANCE Specific m	NET BALANCE Total $10^6 m^3$	NET BALANCE Specific m	REMARKS
1800-1900	0.015	0.016	1.067	0.064	4.267	0.048	-3.200	
1900-2000	0.649	0.966	1.488	2.510	3.867	1.544	-2.379	
2000-2100	1.325	2.393	1.806	3.811	2.876	1.418	-1.070	
2100-2200	0.637	1.317	2.068	1.621	2.545	0.304	-0.477	
2200-2300	0.296	0.653	2.206	0.788	2.662	0.135	-0.456	
2300-2400	0.467	1.042	2.231	0.901	1.929	0.141	+0.302	
2400-2500	0.200	0.550	2.750	0.350	1.750	0.200	+1.000	
2500-2600	0.040	0.110	2.750	0.070	1.750	0.040	+1.000	
TOTALS	3.629	7.047	1.942	10.115	2.787	-3.068	-0.845	

1987

SENTINEL GLACIER

VARIATION OF WINTER, SUMMER AND NET BALANCES WITH ELEVATION

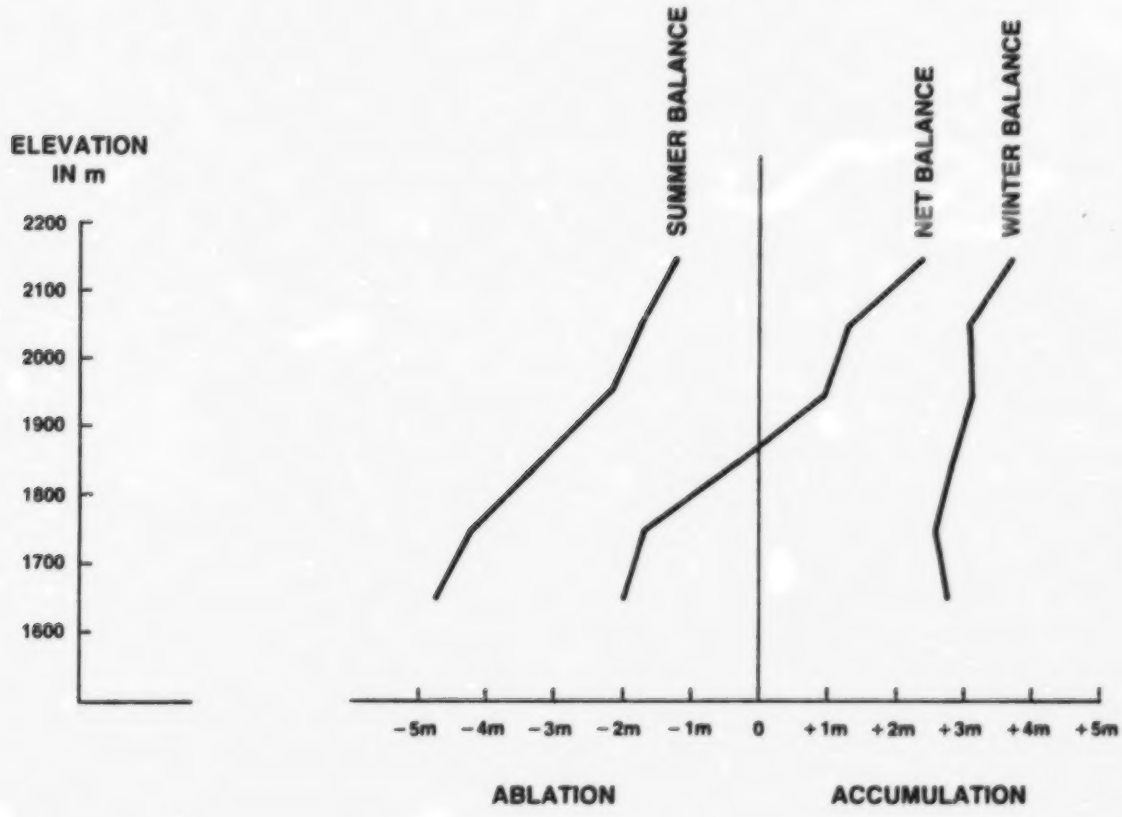

FIG. 2

1987

HELM GLACIER

VARIATION OF WINTER, SUMMER AND NET BALANCES WITH ELEVATION

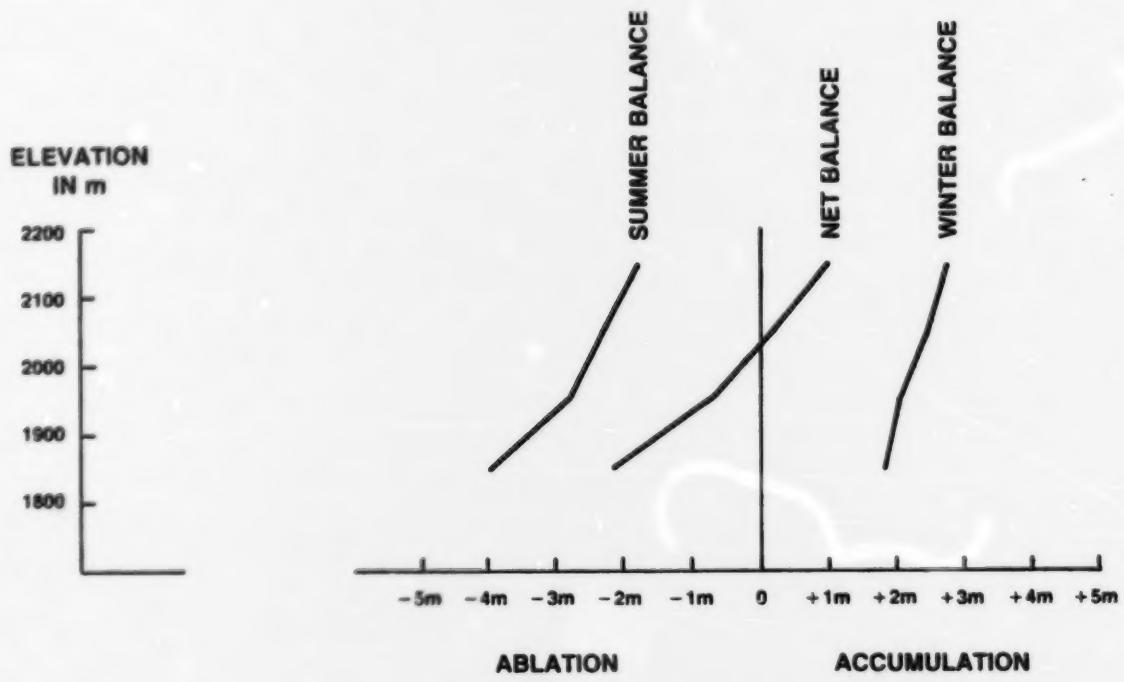

FIG. 3

1987

PLACE GLACIER

VARIATION OF WINTER, SUMMER AND NET BALANCES WITH ELEVATION

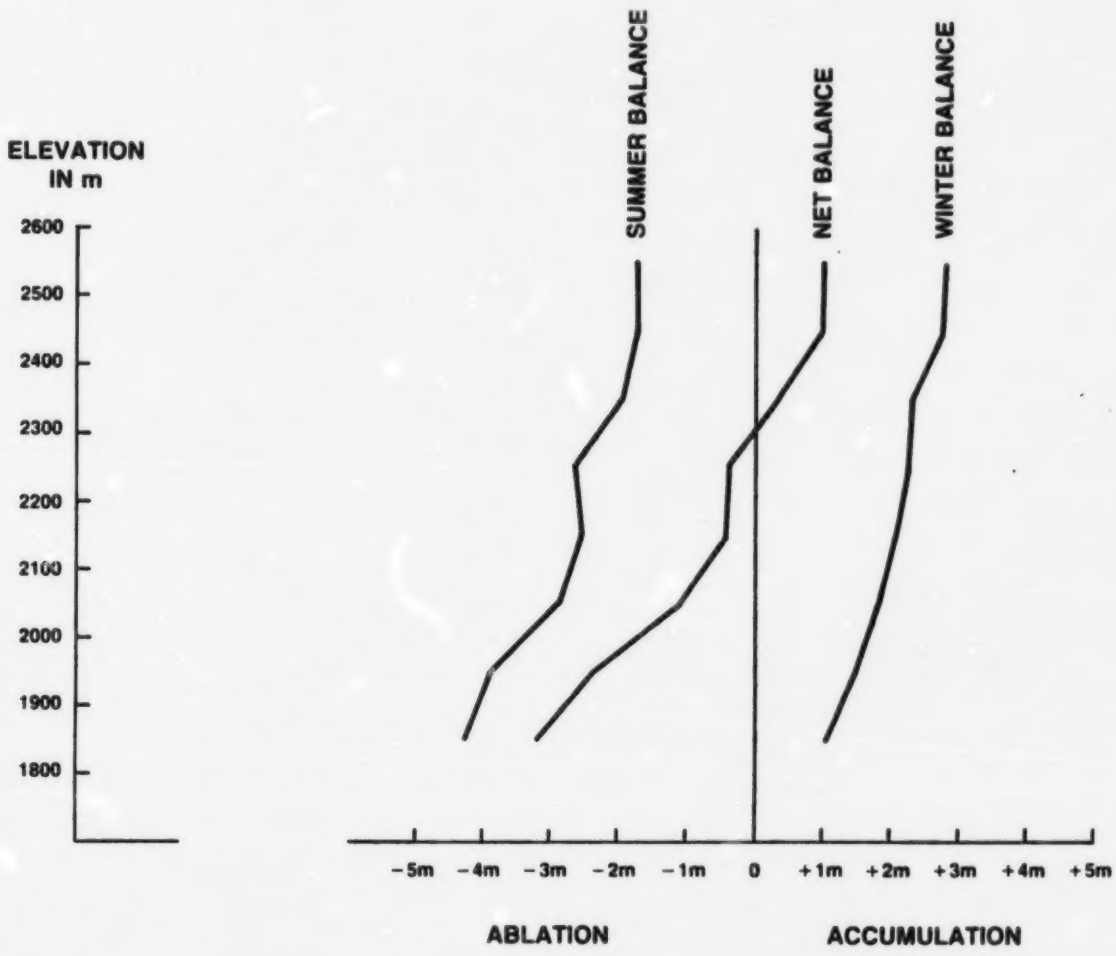

FIG. 4

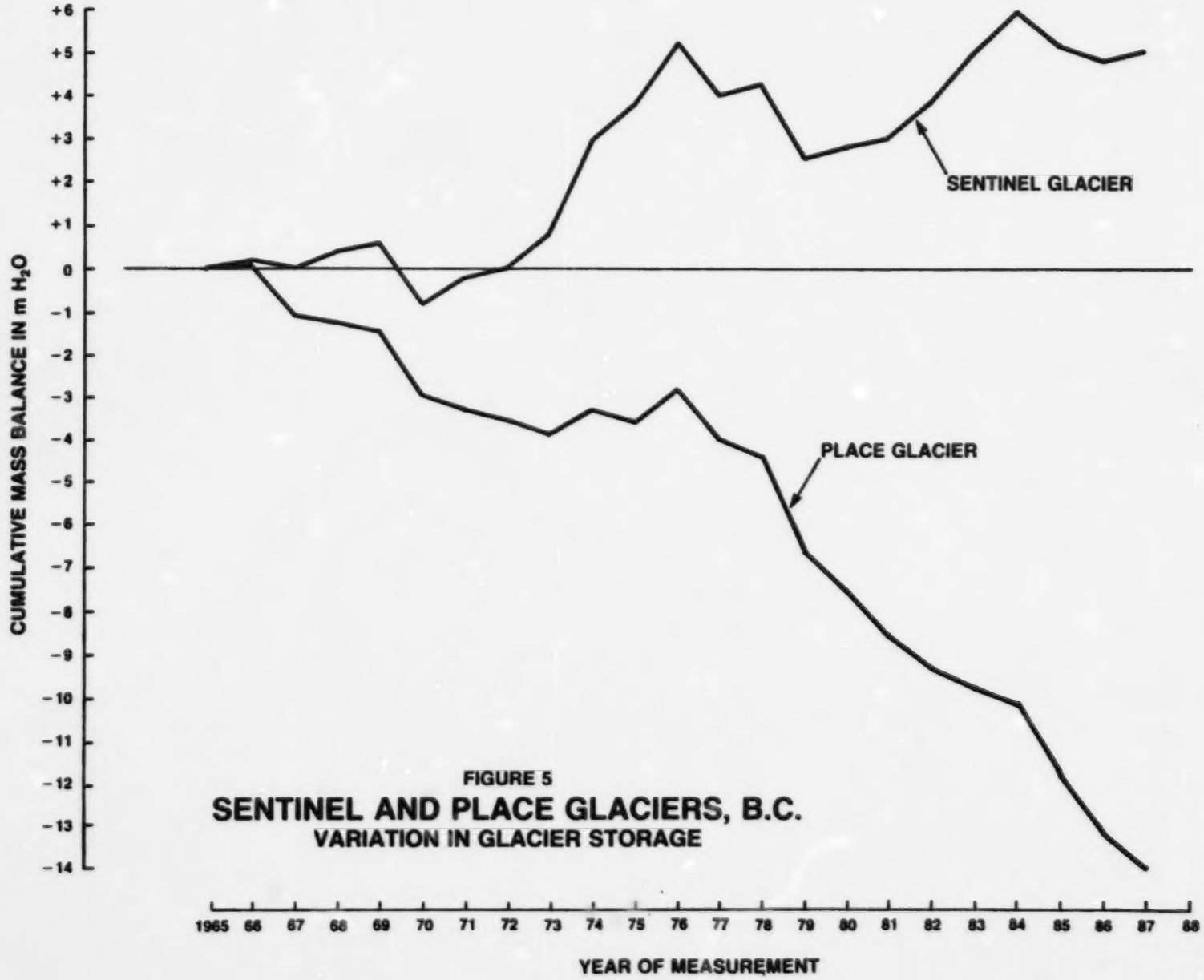

FIGURE 5

SENTINEL AND PLACE GLACIERS, B.C.

VARIATION IN GLACIER STORAGE

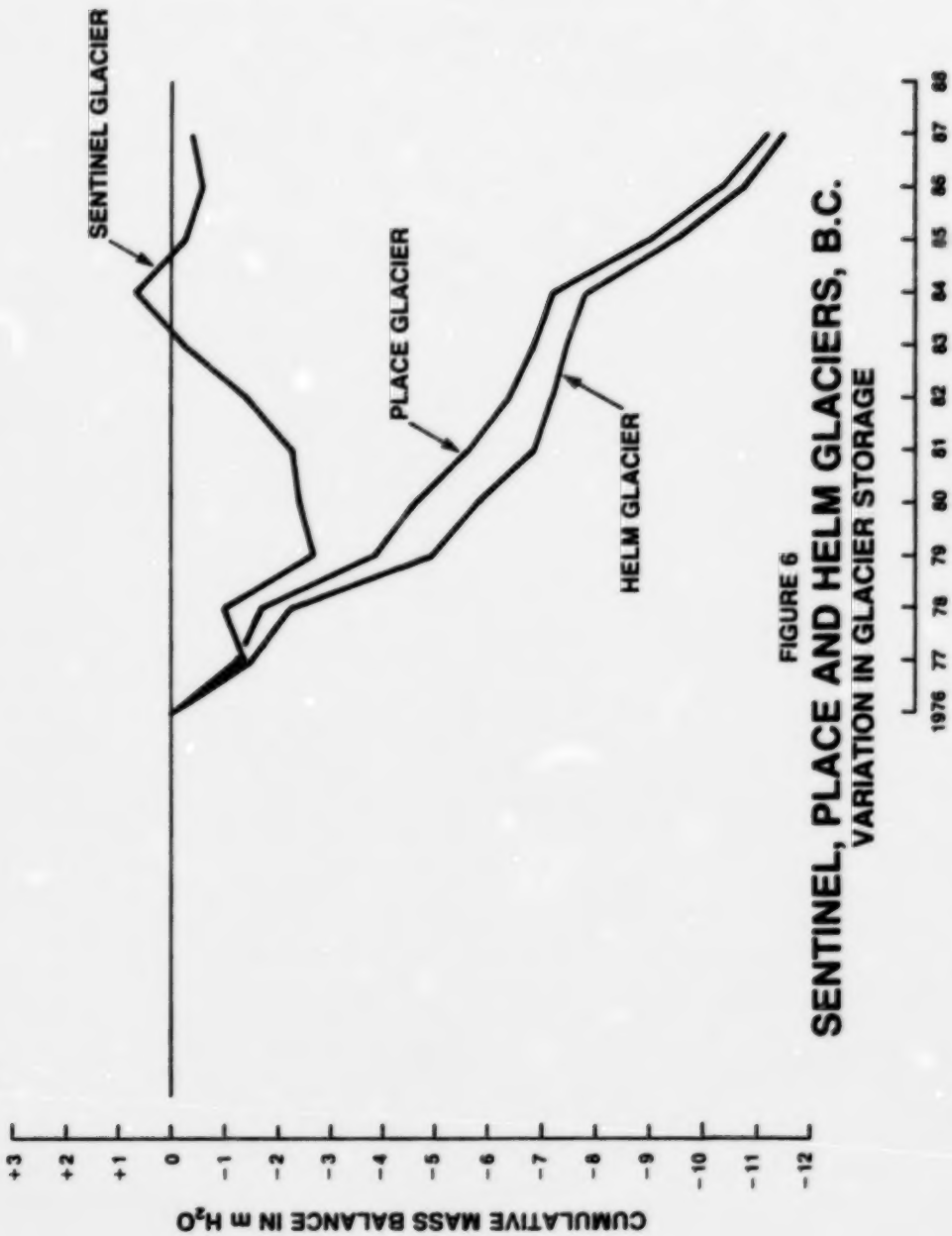

FIGURE 6

SENTINEL, PLACE AND HELM GLACIERS, B.C.

VARIATION IN GLACIER STORAGE